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ABSTRACT

Technological literacy has assumed a significant position on the national educational agenda. An analysis of technology and its potential to transform education is presented in this report. The text opens by delineating and discussing some of the more urgent questions schools confront as they consider investments in technology. These questions include: How does technology fit into the broader picture of education reform? and What basic guidelines can school leaders and staff employ as they seek adequate resources to ensure that their investment in technology will be cost-effective? Views of four individuals chosen from research and practice are offered. Barbara Means, who is a researcher at the forefront of technology and project-oriented teaching and learning, explains how technology can further constructivist teaching and learning. Her view is followed by those of three practitioners who focus on technology as a teaching and learning tool, on structures that facilitate technology, on developing technological competence for teachers and parents, on costs and investments for technology, on ways technology assists project-oriented teaching and learning, on educating parents and families, on refining school structures to support project-based learning, and on planning and budgeting for technology. Strategies for overcoming resistance, developing a knowledge base for teachers, and ensuring equitable access to technology for teachers and students are also provided. (Contains a self-assessment tool for school leaders and 24 references.) (RJM)

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New LEADERS
FOR TOMORROW'S SCHOOLS

Technology and Education: The Current Debate

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In this issue, we focus on technology and its potential to transform education. Clearly, technological literacy has assumed a significant position on the national educational agenda. Policymakers and members of the general public agree that the acquisition of key technological skills is imperative as the nation's schools prepare their students for the workplaces of tomorrow. As a result, school leaders and school staff suddenly are confronted with a myriad of issues as they plan to integrate technology into their classrooms, schools, and districts.

In our opening essay, we delineate and discuss some of the most urgent questions schools confront as they consider investments in technology that could revolutionize instruction and learning. We ask: How does technology fit into the broader-picture of education reform? In the absence of a large and convincing research base that shows direct positive effects on student achievement, what potential does it contain to transform teaching and learning? In what ways will school leaders and staff need to use technology to enhance learning? Finally, what basic guidelines can school leaders and communities employ as they seek adequate resources to ensure that their investment in technology will be cost-effective over the long term?

We follow our essay with the views of four individuals chosen from research and practice, beginning with a researcher at the forefront of technology and project-oriented teaching and learning: Barbara Means. Means explains how technology can further constructivist teaching and learning—although she sounds some cautionary notes. We follow Means with the experiences and observations of three practitioners. Through this blend of expertise and experience from both research and practice, we intend to inform the current discussion and debate about technology as an educational innovation.

We follow these four views with a self-evaluation tool for school leaders and school staff that focuses on the primary issues raised in our essay. The issue concludes with a reference section and Internet sites chosen to extend the knowledge base of our audience.

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Technology and Educational Transformation

Anne Turnbaugh Lockwood

When most Americans think about technology and its impact on their lives, they quickly realize that computers pervade contemporary American society—from fast food establishments to banks to online bookstores. Many Americans make travel arrangements online, pay bills via computer, download information relevant to their work, and send e-mail messages to relatives and friends across the globe. Certainly, technology has linked previously difficult-to-access institutions, countries, and individuals—providing instant access across the yawning divides of time and space.

Given technology's potential to positively affect so many aspects of daily life, it is logical that policymakers and members of the general public feel a sense of urgency that it become a key part of the educational programs and missions of the nation's schools. Technological literacy has been declared nothing less than a national priority by the U.S. Department of Education (1996)—and two billion dollars over five years has been made available through the U.S. Technology Literacy Challenge Fund. These monies are intended to encourage states, communities, and other entities to produce matching funds to support the Department's four goals for literacy in technology:

- All teachers in the nation will have the training and support they need to help students learn using computers and the information superhighway
- All teachers and students will have modern multimedia computers in their classrooms
- Every classroom will be connected to the information superhighway
- Effective software and online learning resources will be an integral part of every school's curriculum (U.S. Department of Education, 1996)

These U.S. Department of Education goals—as well as beliefs about productivity and competitiveness in the workplace—are influencing the pace at which computers and related technologies appear in schools nationwide. A recent Rand report pointed to the presence of approximately one computer per 125 students in U.S. public schools in 1983—as compared to an average of one computer per nine students in 1995 (Glennan & Melmed, 1996).

Yet to policymakers intent upon achieving technological literacy for American students, this progress is not fast enough. They point to the need to prepare students with cutting-edge skills that will equip them to enter the workplace or succeed in college. They emphasize the needs of a new global economy, the skills it requires from workers, and the need for Americans to be competitive in the global marketplace (Secretary's Commission on Achieving Necessary Skills, 1991; President's Committee of Advisors on Science and Technology, 1997). They also express the concern that unless the nation's schools take concerted, aggressive action to integrate technology into their programs, a type of "information apartheid" will result, as NCREL Center Director Lynn Stinnette has observed. In other words, middle-class or affluent children will be equipped with technological skills in part because of the presence of computers at home, while children from low-income households will not enjoy equal technological access and thus will miss out on a significant domain of expertise necessary to prepare them for participation in a technologically oriented future.

In addition to these initiatives intended to accelerate the pace and scope of technology in the nation's schools, the President's Committee of Advisors on Science and Technology recently made the following strategic recommendations to aid educators in their task:

- Focus on learning *with* technology, not *about* technology
- Emphasize content and pedagogy, and not just hardware
- Give special attention to professional development
- Engage in realistic budgeting
- Ensure equitable, universal access
- Initiate a major program of experimental research (1997, pp. 79).

Although not everyone agrees that technology needs to become a key part of schooling (Postman, 1995), relatively few would actively oppose its presence in schools. But when the current reality collides with innovations, the result can be a thorny mix of good intentions and poor outcomes.

As educators, beset with many other day-to-day concerns, begin to contemplate just how they will integrate technology into their educational programs, they face a myriad of pressures and problems. In what ways and for what purposes will technology be used in their schools and districts? How will they pay for it, in times of dwindling resources and state "caps" on school expenditures? How do they ensure that staff will be adequately prepared to integrate it into their instruction? Will it be possible to show direct effects on student achievement as a result of technology use? Will technology spur important innovations in teaching and learning? Finally, will the investment in technology be worth it? Will it deliver what it promises?

In this essay, we focus on these and other questions that school leaders, school staff, and school boards confront as they make significant investments in technology, with the goal of improving the quality of teaching and learning for all students. We begin with a cautionary tale of one district's experience—a fictional composite of the experiences of several schools—in order to illustrate the pressures and decisions that educators confront when they work to integrate technology into their districts' and schools' educational programs.

In the discussion that follows that example, we focus on the role technology plays in widescale educational reform. Can it boost much-needed change? In this section, we discuss the potential that technology offers to educators—the opportunity, as NCREL Director Jeri Nowakowski has observed, "to transform the face of learning." Next, we focus on the issue of professional development for educators that relates to the integration of technology into their instruction. Third, we examine the issue of technology and equitable access for students. We conclude with a brief overview of the planning process for school leaders and school staff as they work to integrate technology into their states, districts, and schools.

One District's Experience: A Cautionary Tale

In Richardsville, a large suburb in the northeastern United States, the implementation of districtwide technology was urged upon the school superintendent by an active and vocal contingent of middle-class parents. These parents were concerned because their children did not have Internet access at school and also because computers were not used throughout the school in every content area. In fact, computers were consigned to a small computer lab where the machines were old and ready to be updated or replaced.

These parental concerns found their way to the superintendent's office and were expressed forcefully at many school board meetings. Board members were lobbied collectively and individually to "get technology into the schools." Richardsville's superintendent, hired on an ambitious and visionary education reform agenda, eyed the financial picture and knew choices had to be made.

The superintendent saw that the district's population was shifting to include growing numbers of students from low-income households. Many of these students were also English language learners. Sharp gaps in achievement were beginning to be obvious. She knew that the district needed much more aggressive parent and community outreach to all socioeconomic, ethnic, and racial groups as well as a new vision for learning that would ensure active, engaged learning for all students. But although the superintendent wanted to

Anne Turnbaugh Lockwood, an education writer and analyst, is an Honorary Fellow in the Department of Curriculum and Instruction at the University of Wisconsin-Madison. She is the author of numerous educational reports, monographs, and articles as well as three books: Conversations With Educational Leaders: Contemporary Viewpoints on Education in America *(State University of New York Press, 1997),* Tracking: Conflicts and Resolutions *(Corwin Press, 1996), and* Character Education: Controversy and Consensus *(Corwin Press, 1997).*

shift instruction and school structures in the district to accommodate an active, student-centered, project-oriented approach to teaching and learning—with the integration of technology as a longer-term goal—she realized she did not have time to develop a coherent plan in which technology would be used as a tool to further her goals. Instead, she would have to concede to public pressure and place technology first.

Largely due to the support of affluent and influential parents, a referendum passed with monies earmarked for technology, specifically for the purchase of hardware and software over a three-year period. Buoyed by this infusion of resources, the superintendent, school board, and building principals planned to implement technology throughout the district. In the first year of implementation, they decided to focus on Charles Lindbergh Middle School, making it the district's demonstration school with a technology focus.

Professional development, teachers agreed, was not adequate to prepare them for their new mission of integrating technology into their instruction.

Many new computers were purchased for the school; software programs for math, science, and language arts soon followed. Recommendations for these purchases were made to the school board by a committee of educational technologists, Charles Lindbergh's principal, and the superintendent. The majority of computers were placed in two spacious computer labs, although math and science teachers each received one computer per classroom.

The school library received three terminals; the card catalog was removed to encourage students to access materials electronically. Teachers participated in a two-day orientation prior to the beginning of school to familiarize them with basic keyboarding skills and computer language. They were told to develop personal plans to use the Internet to access information, to explore the new frontiers offered by technology, and to remember that they were a demonstration school for the district.

The initial excitement and enthusiasm about the new computers began to fade a few months into the school year. Teachers quickly tired of moving either entire classes or portions of their classes to the computer lab. Even more wearing was the task of designing new units—without any assistance or release time—that in some way used or integrated technology. Some teachers resorted to software that put their students in a reactive mode: answering questions on content covered in class in conventional ways, but on the computer rather than with paper and pencil. Other teachers decided the computers might be something they could use at some later date, but for now the constraints of their instructional planning time did not permit experimentation. Most teachers concurred privately that their own technological skills simply were not advanced enough to use technology with their students with any sense of confidence or purposefulness in the classroom.

The math and science teachers who received one computer per classroom quickly decided that one computer was not nearly adequate for their students. Instead, they used the computers to maintain grades and attendance records for their students. The teachers in other content areas, forced to share one computer with other teachers in a public area consigned for brief break periods through the day, never found the time or the opportunity to engage with the machine.

Professional development, teachers agreed, was not adequate to prepare them for their new mission of integrating technology into their instruction. Although a few teachers—stalwart believers in the benefits of technology—worked long hours to devise ways to integrate computers into their classroom instruction, many others fell back upon what they had done in previous years.

As for the three terminals in the instructional media center, students formed long lines to look up information and locate books. Since the card catalog had been removed, the librarian found herself mediating between students hassling each other for terminal access during library time.

At the end of the school year, Charles Lindbergh's principal asked for monies for professional development for the next year, but was told that Phase Two of the technology implementation did not include additional funds for that purpose. Instead, computers would now be placed in additional schools throughout the district—with the same preliminary two-day teacher orientation. The results after one year with technology? In their informal conversations as well as in faculty meetings, Charles Lindbergh's teachers agreed that technology had many possibilities, but it simply wasn't practical in their situation. Computers, they believed, should be used by technophiles with special knowledge and expertise—such as the few teachers who continued to believe in the added value technology brought to their instruction and to students' learning.

The experience at Charles Lindbergh Middle School demonstrates key lessons for educators confirmed by research and other skilled observations (Means & Olson, 1997; Glennan & Melmed, 1996; President's Committee, 1997). The major pitfalls were:

- Lack of a coherent instructional vision in which to embed computer technology
- Inadequate monies for professional development with little forethought or teacher input on teachers' needs
- Lack of release time for teacher planning for new units integrating technology
- Physical grouping of computers almost solely in computer labs, with insufficient numbers of computers in classrooms and the library
- Failure to draw upon the technical expertise of key teachers who had "bought into" technology, using them as trainers and peer coaches within the school
- Insufficient funds to update machines and provide continuous professional development

Technology and Education Reform: Changing the Face of Learning

This cautionary tale illustrates what can happen to well-intentioned individuals who embrace technology for its own sake—rather than considering technology as a core component of education reform or less broadly, as a key part of a district's instructional vision. In what ways does technology link with the ambitious goals of education reformers?

Instruction, education reformers argue, needs to change to fit the needs of contemporary society, which is increasingly complex and pluralistic. More than one generation of education reformers has indicted conventional teaching practices that focus on drill, memorization, and recitation, and on the student as passive recipient of information (Barth, 1990; Newmann, 1996). These reformers—and blue-ribbon commissions as well—all argue that new ways of configuring education should emphasize the student as an active participant in his or her own learning.

All of these reformers, researchers, and commissions contend that this shift in instructional practices—and in school structures that support these practices—will increase student achievement; heighten both teacher and student engagement in their work; and develop new, much-needed skills, such as problem-solving and higher-order thinking, that will be imperative in the marketplace of the future (Barth, 1990; Jones, Valdez, Nowakowski, & Rasmussen, 1995; Newmann, 1996).

An unacceptable number of students are in crisis; U.S. schools must respond so that their futures are not imperiled. Along with this focus on new ways of structuring teaching and learning comes a sense of urgency about educating those students termed "disadvantaged": youth whose families fall below the poverty line, who may be English language learners, who also may arrive in U.S. schools from different cultures, or whose families are so absorbed with basic survival that they see few options for themselves. These are the students who present educators with needs that the conventional educational program fails to address.

While researchers disagree on the specifics of programmatic responses targeted to these students, they usually concur that all students, particularly students most at risk of academic failure, need a supportive and nurturing environment (Wehlage, 1989). They benefit from a school culture that combines academic press and personalism as well as from vigorous efforts to connect with parents and families in an effort to bring them into the student's schooling (Sebring, Bryk, Roderick, Camburn, Luppescu, Thum, Smith, & Kahne, 1996; Slavin, 1996). Challenging curricular content is mandatory—rather than a focus on remediation—so that they do not tune out of the traditional educational experience and drop out of school entirely (Levin & Hopfenberg, 1991; Slavin, 1996). Efforts to make instruction "culturally relevant" (Ladson-Billings, 1994) also bond students to school and to learning.

What evidence supports a belief that technology can assist in achieving these goals? Researchers interested in the intersection of technology and reform believe that technology can be a powerful tool with which to effect the broader goals of

education reform. At the same time, they caution that technology's purpose—one that advances constructivist or project-oriented teaching and learning—needs to be kept at the top of the agenda as educators plan for technology in their schools and districts.

Constructivist learning can become the vehicle through which both educational reform and technology integration can be accomplished. In the constructivist view of learning—central to the goals of most education reformers—student work is authentic and challenging (Means & Olson, 1997) and teachers' roles shift as they become facilitators of information. Collaborative work among students becomes much more common as the teacher moves between groups as a coach, discussion leader, and guide. Authentic learning also is more complex than conventional, didactic forms of learning (Means & Olson, 1997, Newmann, 1996)—with the gratifying result that students become much more engaged in what they learn and in the solution of real-life problems.

In Means' research on nine sites that focused on integrating technology into a constructivist approach to teaching and learning, she and her colleagues found positive, teacher-reported effects on students such as increased motivation and willingness to engage with content, improvements in student performance, increased ability to handle more complex assignments, and the creation of higher-quality products (Means & Olson, 1997, pp. 135–140). Effects on teachers reported in the same study included heightened and increased collaboration among staff, support for teacher interactions with external collaborators and resources, and an increase in teacher professionalization (pp. 151–158).

Computer technology in schools can also exert pressure to change existing and ineffective structures so that a project-oriented vision of learning can be realized. In its development of a national strategy to assist the integration of technology into schools nationwide, authors of a report for the Rand Corporation pointed to instances where computer technology has

- tailored learning experiences more sharply to learner needs and abilities
- provided students with access to resources and expertise outside the school, both enriching their learning and extending the time devoted to learning
- supported more authentic assessment of a student's progress
- assisted schools in managing and guiding the learning activities of their students (Glennan & Melmed, 1996, p. 4)

The Rand researchers also found sites where restructuring was assisted by the presence of technology. In particular, they found that communication among teachers as well as between school staff and parents was enhanced by the presence of e-mail. However, they caution that current research on the effects of technology on restructuring, reform, and student performance is not conclusive (1996, p. 5), although it is promising.

The research on the effects of computer technology on students—particularly in reference to constructivist teaching and learning—is impeded by technical difficulties. The President's Committee of Advisors on Science and Technology concluded in a recent report to the President that empirical research on technology as applied to constructivism in education has several complicating factors, which include how positive educational outcomes should be defined and measured to determine the effectiveness of differing approaches (1997, p. 90). They also point out that research progress has been slowed by lack of funds (p. 90). As one of its recommendations, the Committee urged the formation of a research agenda to examine the effectiveness of technological applications to constructivist learning.

Technology and Professional Development

As teachers begin to work with technology, they will need new skills and different ways to conceptualize their practice. What will teachers need in order to work with students using new forms of computer technology? In what ways do they need to shift their instruction to accommodate new forms of technology? Does technology dictate the instructional shifts, or should teachers control the ways in which they use technology? Are there particular ways in which technology can be used with students who arrive at school especially needy?

In part, confusion over how and what teachers should do with technology stems from the public emphasis on workplace preparation. Teachers understandably want to see how technology can help them accomplish their instructional goals and refine their practice. An emphasis on technology as a type of vocational preparation can lead to a belief that technology for its own sake is sufficient, that the use and placement of computers is not as critical as their presence in schools, and that as long as students are occupied in some way for some portion of the school day on computers, they are learning valuable things.

The reality, as critics point out, can be quite different (Postman, 1995; Oppenheimer, 1997). Simply having computers in a school building—and placing children in front of them—is no guarantee of educational excellence. Software can be just as didactic and conventional as paper-and-pencil

worksheets. Critics and concerned observers point to previous innovations in technology, such as radio and television, and the effects they were supposed to have on schooling (Cuban, 1985; Oppenheimer, 1997). When they failed to produce the desired results, teacher resistance or bureaucratic practices were blamed, rather than the technology or the ways in which it was used.

In order for computer technology to succeed in the schools of today and the future, teachers need to master new skills and be supported as they acquire those skills. Approximately 62 percent of U.S. teachers currently report using a computer regularly for instruction (President's Committee, 1997, p. 47). It is important to qualify that this use of computers frequently occurs in the context of teaching students *about* computers, rather than working with them *on* computers. Computers are also used most frequently for basic drill, rather than for the sophisticated problem-solving and information-retrieving purposes that policymakers and the public believe is important.

This situation could be eased considerably if adequate monies for professional development were budgeted at the outset of any technology plan—with provisions in future budgets as well for an ongoing amount of adequate funds so that teachers can continue to learn new skills as technology continues to develop. Means and Olson (1997) estimate that at least one-third of school budgets should be devoted to monies for professional development for teachers.

The content of teacher professional development is also critical. Rather than focusing narrowly on technical uses of computers—which frequently is off-putting to teachers—an approach that emphasizes the link between computers and how teachers might use them in their instruction is generally the most beneficial (President's Committee, 1997, pp. 48–49). One example of professional development targeted specifically to the needs of teachers as they integrate technology into their instruction is an NCREL-developed course, *Learning With Technology* (North Central Regional Educational Laboratory, 1997). Course participants view video segments of real classrooms where technology is successfully implemented and develop instructional activities that use technology to promote engaged learning and heightened student achievement.

Professional development needs to be supported by release time and special expertise. Professional development alone, offered in workshops or inservices, is not sufficient. Teachers need ongoing support, such as that offered by onsite technology coordinators who can offer special expertise with hardware problems that can delay or postpone an entire instructional unit. These technology coordinators, however, need to be carefully chosen so that they can communicate effectively with teachers about their instructional needs and not be consigned to repair work alone (Means & Olson, 1997; President's Committee, 1997).

Perhaps the greatest obstacle to teachers using computers is the lack of time for planning and incorporating such a massive innovation into their practice. If one considers that teachers average ten minutes of preparation time per hour they teach, introducing novel concepts and allowing that amount of preparation time is obviously not sufficient (President's Committee, 1997, p. 52). Some estimates indicate that it will require three to six years for teachers, on average, to integrate technology into their classrooms and teaching practices. Ongoing changes and developments in technology most likely will extend this time (President's Committee, 1997).

The lack of time points again to the intersection between technology and reform. If schools are serious about integrating technology into their classrooms, they may have to consider structural shifts to accom-

Perhaps the greatest obstacle to teachers using computers is the lack of time for planning and incorporating such a massive innovation into their practice.

Cost is frequently considered the biggest barrier to widespread technology use. School administrators already hard-pressed to find monies for existing programs can find this barrier almost insurmountable . . .

modate increased teacher training and preparation periods. Such shifts also aid in-depth work, extended projects, and collaborative work among peers (Lockwood, 1997; Means & Olson, 1997; Newmann, Secada, & Wehlage, 1995; Newmann, 1996).

Preservice education also needs to accommodate the burgeoning use of technology in education. Teacher education programs also face another task: preparing graduates who can enter the job market with at least basic technological skills, such as keyboarding, database searches, Internet searches, a knowledge of e-mail, and an understanding of basic word processing. If preservice programs can also develop ways in which prospective graduates are encouraged to think about technology as a tool to use in their instruction, an infusion of beginning teachers in the workforce could aid the entire transition to technology in the schools (President's Committee, 1997).

Technology and Equity

Although advocates of technology argue that it has the potential to eliminate or minimize background disparities among students, ensuring equitable access to technology is a challenge to educators. One of the concerns about technology is that computers are expensive in any setting—and computers at home tend to cluster in middle-class or upper middle-class households. While students from low-income households might find particular benefits from home computers, such access is not usually available. This schism between economic groups could further polarize technological opportunities into the "haves" and "have-nots."

Yet one of the beliefs about technology expressed by policymakers is its potential to equalize opportunities, particularly for those students considered to be disadvantaged. How can equitable access to technology be assured?

One straightforward way to assess equitable access is to measure computer density, that is, the computer:student ratio. The President's Committee of Advisors on Science and Technology (1997) reports that schools with higher computer densities typically provide broader access to technology in general, as well as network-supported technology and multimedia applications (p. 67). Examining computer density in schools with high percentages of students from low-income households or with other risk factors will be one way to determine whether equity is, in fact, being achieved.

However, computer density alone can be misleading. The authors of this report also emphasize that it is necessary to determine the extent to which computers and other technological applications are used by different groups of students (1997, p. 68). While measuring student hours on computers in school can be one indication, risk factors can also predict how their time may be spent—so-called disadvantaged students spending much more time in drill and other students working exclusively with constructivist applications of technology (1997, p. 68).

Some schools have met the equity challenge with imaginative programs for computers to be used at home, such as checking out laptops or making laptops integral to certain classes and shared among students. Others link parent classes with older computers signed out for home use on a contractual basis with the school. While these computers may lack the sophistication of the current iteration of computers, they can be used for basic word processing and spreadsheet applications for parents. Children in these households can also benefit from having an at-home computer for their homework and, in fact, can learn from teaching their parents basic computer skills.

Budgeting for Technology: Some Guidelines

Although issues related to cost for the implementation of technology can be complicated, a few basic guidelines prevail. While it is beyond the scope of this publication to present a detailed outline for budgeting for technology, resources exist that do provide such information. However, a few general guidelines should be considered as schools embark upon costly investments in their technology infrastructures.

Cost is frequently considered the biggest barrier to widespread technology use. School administrators already hard-pressed to find monies for existing programs can find this

barrier almost insurmountable—and as a result, can make well-intentioned decisions that do not produce the desired results.

Several studies have produced estimates of current and projected expenditures for technology in U.S. public schools (Glennan & Melmed, 1996; Harvey, 1995; Keltner & Ross, 1995; McKinsey & Company, Inc., 1995; Means & Olson, 1997; Moursund, Bielefeldt, Ricketts, & Underwood, 1995).

These studies project technology expenditures to range from annual costs of $7 billion to $28 billion nationwide. These costs are based on the amortization of capital equipment and other start-up costs over a five-year period (President's Committee, 1997).

The President's Committee of Advisors on Science and Technology points to an analysis by Henry Becker, in which he estimates technology expenditures that would turn teachers into "exemplary users" of technology (1997, p. 62). These expenditures would include structural changes such as reducing average class size to 20 and allocating sufficient resources to ensure adequate teacher planning time so that they would be enabled to use technology in their classrooms. Becker's analysis is also based on a computer ratio of one computer to two students—a considerably denser ratio than in most schools.

Becker projects an annual cost of $1,375 per student in personnel costs with an additional $556 annual cost for hardware, software, and maintenance (President's Committee, p. 62). Although these costs are significant, a key point of his analysis is that they are not higher than costs incurred by educational reform projects.

The purchase of hardware and software—often considered as the only expenditures a district has to make—is a misleading and faulty way to conceptualize the costs related to computer technology (President's Committee, 1997; Means & Olson, 1997). Instead, school leaders and board members need to think long-term, adding in adequate monies for professional development; for repair, maintenance, and replacement of equipment as it becomes outdated; and for the hiring of technical support personnel. In short, implementing technology to support a vision of learning is a costly investment and cannot be done inexpensively or the whole endeavor's success can be jeopardized.

As the President's Committee of Advisors on Science and Technology notes:

> If we do not wish to turn our schools into junkyards for expensive, but unused computer equipment—a scenario that is, unfortunately, far from uncommon at present—it is important that budgetary constraints and wishful thinking not lead us to buy the educational equivalent of a fancy automobile without allocating funds for gasoline, repairs, or a driver education class. (1997, p. 63)

Clearly, the integration of technology with education reform—with goals such as providing competitive skills for students so that they can create productive futures for themselves—presents significant challenges for school leaders, school staff, boards of education, and policymakers. Careful, clear planning will ensure that computer technology becomes a tool school staff can use to authentically teach the nation's students—and impulsive, reactive decisions could result in yet another promising innovation that will be discarded—its full potential never realized.

References can be found in the Refernce Section at the end of this issue.

"We are now at a point where we must educate our children in what no one knew yesterday, and prepare our schools for what no one knows yet."

Margaret Mead

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Views From Research and Practice: Technology's Transformation of Teaching and Learning

Anne Turnbaugh Lockwood

What guiding principles about the integration of technology can be learned from the observations, data, and experiences offered by both research and practice? To answer that overarching question, we present a series of interviews drawn from research and practice. First, through our interview with Barbara Means, an authority on technology in education, we provide a framework through which to view technology as a tool to transform teaching and learning—and to advance the goals of education reform. Means discusses her research findings and highlights their relevance to current educational settings.

Next, we present the experiences of two schools: Northbrook Middle School in Houston, Texas, and Community High School in Ann Arbor, Michigan, through the words of their principals, Laura Schuhmann and Judy Conger, respectively. Both Northbrook Middle School and Community High School have succeeded in their integration of technology into a vision of learning that is constructivist and project oriented.

We conclude by presenting the experience of a district that is working in active partnership with NCREL and other area institutions to design and implement cutting-edge uses of technology districtwide. Pi A. Irwin, Superintendent of the Glen Ellyn School District in Glen Ellyn, Illinois, discusses how she guided the district from its vision for learning through the implementation of technology as a tool to enhance and support that vision.

Barbara Means: Technology and Constructivist Learning

Who controls technology—and how will it be used to further teaching, learning, and education reform? This, to Barbara Means, is one of the most significant questions facing educators as they move to integrate technology into schools and classrooms. It also is a question that could be overlooked by educators and parents enamored with the raw power and potential of technology—as if its presence alone is sufficient to transform schools and classrooms.

"Is the student controlling the technology and making the decisions?" Means asks, "or is the technology making the decisions with the student providing responses on demand?"

This is an acute distinction, she believes—and if it is kept in the forefront as educators plan for technology in their schools and districts, many potential problems can be avoided. "It certainly is possible for both students and adults to waste a lot of time with technology," Means says candidly. "I have seen some estimates of millions, if not billions, of dollars wasted in offices as people browse aimlessly on the Internet."

Barbara Means is an educational psychologist whose research focuses on ways in which technology can support students' learning of advanced skills as well as the revitalization of classrooms and schools. Currently, she directs research and evaluation activities for two technology-supported innovations: the GLOBE program, in which thousands of students around the world collect data on their local environments and use the World Wide Web to share that data with each other and with earth scientists, and Silicon Valley Challenge 2000, a public-private partnership to reform school systems and promote student learning through the use of multimedia technology. Dr. Means' earlier work included directing the National Study of Technology and Education Reform, which produced the volume Technology and Education Reform: Views from Research and Practice, *published by Jossey-Bass. She also co-edited* Teaching Advanced Skills to At-Risk Students *(with Carol Chelemer and Michael Knapp) and co-authored* Comparative Studies of How People Think *(with Michael Cole). Dr. Means conducts her research within the Center for Technology in Learning at SRI International (in Menlo Park, CA), where she also serves as Vice President of the Policy Division.*

"Using technology leads to greater pride in their work, in their classrooms, and in their schools. Having it as a part of their classrooms provides considerable motivation to work and engage in learning."

In schools, she has observed examples of equally random and unproductive time spent on computers—remarkable for quantity rather than quality. "I've seen students spend hours editing the color covers for their research reports, literally pixel by pixel, before they even begin to write the report," she adds. "Or they may spend a lot of time playing or developing computer games with no obvious intellectual content."

Both physical considerations—such as where computers are placed in schools—and staff autonomy and input in technological decision making are key, she believes. For example, if computers are housed solely in separate labs, there is a greater risk that they will remain separate, detached from daily classroom instruction. Or if teachers do not view technology as a support for the instructional life that occurs in their classrooms or do not believe technology can have a positive influence on teaching and learning, a significant investment can be wasted. "Resources also can be wasted in places where technology is mandated," she warns, "or where the teacher doesn't have strong instructional goals. In such schools, students often are monitored on whether they are using the technology, but not on how they are using it, or what they are learning from the experience."

These cautionary notes aside, Means is encouraged by technology's potential not only to transform the quality of instruction and learning—but also to tilt education reform in a positive direction. When used to enhance project-oriented learning, she argues that student-developed products can take on new meaning and depth.

In fact, student enthusiasm for real-world applications and uses of technology is one of its greatest strengths, she says. "We interviewed students in focus groups in our research," she notes, "and they speak about power when they discuss technology. When they use technology, they are able to amplify the effects of their own actions to turn their schoolwork into real products.

"Using technology leads to greater pride in their work, in their classrooms, and in their schools. Having it as a part of their classrooms provides considerable motivation to work and engage in learning."

Technology and Constructivism

How do district and school personnel move from an impressionistic view of technology as a mysterious, powerful force to a sharp, clearly defined picture of it as a tool that must be carefully employed? How might skeptical school staff, weary of superficial inservices, believe that technology can transform the quality of student learning—particularly when research pointing to technology's impact on student achievement is scant?

In her reply, Means points to some research that supports the contention that technology can have a direct positive influence on student learning. "We do have some evidence that an innovation supported by technology can help improve learning," she says. "The Jasper Adventure Series; some of the work done with Computer-Supported Intentional Learning Environments; and Genscope, which deals with genetics, are all examples of this.

"But the problem," she emphasizes, "is that policymakers want an across-the-board assurance that technology is the magic bullet. They want to believe that if educators only put technology in the schools, automatically learning will improve. We know enough to know that isn't likely. It is the package of instruction and technology together that makes the difference."

Teachers, she observes, have legitimate concerns about instructional goals and how those goals mesh with uses of technology. "They want to see evidence that technology can be part of an innovation that helps students like theirs learn the kinds of concepts and skills that they believe are important in

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their particular classrooms, whatever those may be. This is a message that needs to get out," she adds, "and this is why we need a stronger research base looking at different grade levels and different content areas. We need to understand what combination of instructional interventions with technology supports makes a difference."

Teachers can be introduced to this potential, rich research base, she suggests, through a variety of imaginative sources. "The typical journal article may not be the most effective mechanism," she says dryly, "but conference presentations, Web site presentations, or visits to schools that use technology effectively are all ways that can affect teachers' practice. These mechanisms are also more comfortable for teachers."

Unlike other passing trends that educators have experienced, technology is not going to go away, she emphasizes gently. "Teachers are going to see that this is not one of those things that will pass. The technology movement is gaining momentum; there is considerable public support for providing students with technology access and Internet access as well.

"But teachers need to ask what uses of technology make sense in their schools—and how they want to go about achieving their goals."

These questions, Means argues, cannot be separated from questions about existing school structures and how they might be changed to accommodate a different instructional focus. "Teachers and school leaders also need to consider how their schools should be structured. For example, in one of the case schools that I looked at in my research, staff didn't begin with any consideration of technology. Instead, their focus was an existing site council process with teacher committees that worked on different areas of the school."

This school, Means adds, had a predominantly Spanish-speaking student population and was concerned about their transition to English. "One of the teachers suggested using technology as a way to promote literacy in English, and as they explored how that might work, it fit nicely into the school plan they had developed. That is a very effective way to go."

Not only does a combination of instructional goals and a consideration of school structures help power the use of technology, it also gives teachers a base to make intelligent choices about what type of technology will work for their needs, Means adds. "It gives school staff a justification," she says, "to not necessarily jump at every technology gift that is offered to the school. In some areas, the schools get a lot of contributions, and these gifts may not fit very well with the goals the school has set for itself.

"If school staff haven't thought through their instructional goals and how their school structures support both their goals and their use of technology, it is difficult for them to decline something such as a stand-alone computer lab connected to the Internet."

Changing to Project-Oriented Teaching and Learning

While some teachers might entertain superficial enthusiasm for technology in their classrooms—without devoting sufficient thought to how it might be best used—others will resist project-oriented or constructivist approaches to teaching and learning, Means points out. "A number of teachers are skeptical about that approach," she says, "and don't feel prepared for it. It requires a major shift in how they think about their curriculum, their instructional approach, how they organize their classrooms, and how they think about discipline.

"That," she adds, "is a far more profound change than just introducing technology. If you have made the shift to project-based learning, then introducing technology is a relatively straightforward elaboration of the basic model. But if you haven't made that shift to project-based learning, and you try to shift everything at one time, it is an overwhelming process. To further complicate the picture, sometimes it is an involuntary process, which concerns me."

When teachers are forced to introduce technology into their classrooms—and also pushed to shift their instruction to a project-oriented approach—the result is nothing less than a recipe for disaster, Means believes. "The most effective combination for implementation is a combination of top-down and bottom-up. A set of priorities can come from the top as well as support for the basic structure, such as support for teachers who use their own time to get training in the technology use area.

"But at the same time," she cautions, "I am very wary of top-down mandates. It is important that groups of teachers think about their individual schools and their practice—and then make their own choices. Certainly, the best uses of technology are well integrated with instructional goals. A great deal also depends on the creativity and devotion of the individual teacher combined with the excitement he or she derives from it. Those qualities can't be mandated."

Developing a Knowledge Base

What do teachers need to know before shifting their instruction to a project-based approach that incorporates technology as a support? Are there specific attitudes or dispositions necessary for the challenge? How can school staff best prepare themselves?

"School leaders also need courage. On the practical side, they need to set an example by using whatever tools are built into the school for their own work, such as e-mail, word processing, and so on. But school leaders also need to be able to help teachers through the process of articulating the connection between technology and their instructional goals—and broader school reform goals."

In her response, Means points to courage as the key factor—a type of pluckiness that will get teachers and other school staff over the rough places. "Teachers need to have a good courage factor," she notes. "They don't need to know how to use every piece of software, but they need to have used some software and feel confident that they can figure things out. If they have that attitude—especially if they are willing to turn to colleagues and students for help—they can accomplish a great deal."

School leaders need a similar sort of mettle, she believes. "School leaders also need courage. On the practical side, they need to set an example by using whatever tools are built into the school for their own work, such as e-mail, word processing, and so on.

"But school leaders also need to be able to help teachers through the process of articulating the connection between technology and their instructional goals—and broader school reform goals. They also need to be willing to do what they can to structure both the school day and professional development opportunities in ways that support teachers as they work to integrate technology into the curriculum."

Overcoming Barriers and Obstacles

As school staff contemplate and begin to integrate technology into project-oriented learning, what barriers do they face? How might these be overcome?

Means points to the lack of time teachers and school leaders have to effect substantive change. "Anything new is complex. Teachers have many competing demands and very little discretionary time during the regular school day."

As a result, usually only a few will be interested in taking on something new or untried, she observes. "In schools that have been successful using technology to further project-oriented teaching and learning, there is a critical mass of teachers using technology well and we usually find provisions for supported time for preparation and planning."

For example, one middle school studied by Means and her colleagues gave teachers a 90-minute preparation period twice a week: one period with their team colleagues and the other period for individual preparation. "This came about in recognition of what they were asking teachers to do through technology," she says. "In a project we are working with now, the Challenge 2000 Multimedia Project in Silicon Valley, grant funds are used to support the teachers in having a joint workday once a month."

Teachers from 30 different schools, she explains, come together monthly for a day to consult with their peers. "They teach each other and they sharpen their skills related to integrating technology into their practice. These teachers also had previous separate workshops that provided training on specific pieces of software and also on project-based learning. But those training experiences weren't enough. Teachers need an ongoing experience where they consult with peers and observe what others are doing in their classrooms."

Goals for Technology

While the public might believe that technology belongs in schools in order to prepare students for the workplace, teachers usually prefer to focus on the use of technology to further specific instructional goals. How might this difference be resolved? Or is it a discrepancy that demands a resolution?

To Means, this apparent conflict between what the general public wants from technology in the schools—and what school staff want and need from technology—is misleading. "It is more apparent than

real," she says. "One way to look at it is to ask: What do I, as a parent or an employer, want students to learn from using technology in their schools?

"Today's seventh grader won't use the same software or possibly even the same Internet when he or she enters the labor market in the year 2007. But as someone concerned with the economic well-being of that individual—or with the U.S. economy—I would want a student who could make judicious choices about what technology tools to use."

Courage again enters the picture, as well as a certain confidence. "We want our students to be confident they can handle technology and have the courage to do so. As a teacher, I certainly can help students acquire these skills in the course of learning almost any academic content."

Bringing parents' and teachers' goals together, she maintains, is aided if schools and teachers can articulate clearly what aids students in learning or, as she puts it, "helps them in learning to learn with technology."

Integrating Technology and Project-Oriented Learning

What general guidelines are helpful to both teachers and school leaders as they work to integrate technology and project-oriented learning? Are there obvious hazards to avoid? Are there central questions for contemplation and reflection?

Means points first to documents available to assist schools in their technology planning *(see references at end of issue)*. "The most basic place to start is to take the attitude that technology should not be a separate effort. It should be part of a district's education reform goals. It is also helpful to assess where a district or school is with its improvement process and ask how technology can support that vision for learning.

"It is important to ask where students will gain some of the basic skills they need in order to use the technology. Will they try to learn these in every class? Will teachers work with them in a more concentrated way in a particular grade or particular class?

"Another issue to address is how teachers and other school staff can be sure that their implementation of technology will be one that increases equity rather than inequality. We certainly don't want just one group of students to have access to technology," she adds. "The more parts of the curriculum that are supported by technology, the less likely that it will become the bailiwick of just one segment of the student population. Other issues include, How can we make sure that technology isn't something on the side—handled only by the technology coordinator—while teachers ignore it in terms of their daily practice? What supports will teachers have when something doesn't work? Who can they turn to?"

One obvious pitfall can be avoided if schools and districts budget wisely for technology, she points out. "In general terms, the investment that schools and districts make in the hardware and software required for any technology start-up is less than half the money that ultimately will be needed," she emphasizes. "Schools need to plan for recurring costs. There will be a need for maintenance and for upgrades every year. That has to be thought about as it is in business, in the sense that those recurring costs must be calculated into the budget.

"Planning time for teachers to learn to use the technology also must be part of the budget," she notes, "with usually about a third of the funds spent on technology used solely for teacher development and support. It is very important to remember that one shouldn't take the number of students or classrooms and multiply them by cost per computer or Internet connection to estimate a technology budget. It is not that simple—and many schools have been caught in this trap."

"The most basic place to start is to take the attitude that technology should not be a separate effort. It should be part of a district's education reform goals. It is also helpful to assess where a district or school is with its improvement process and ask how technology can support that vision for learning."

". . . we need to build a knowledge base to find out which technology-supported approaches work best for what kinds of learning goals with what kinds of students."

As schools look for high-quality professional development to support the integration of technology into project-oriented learning, what should they seek? How might they guard against individuals or companies who promise much but offer little that is substantive?

"There are many good professional development opportunities in this area," Means says. "I would look for programs where technology use is integrated with something else. For example, programs that teach high school biology with technology tools, or programs that teach mathematics with graphing calculators or computer supports. The key is the integration of technology skills with the content area. By doing this, schools will avoid 90 percent of the hucksters selling professional development for technology because they are not individuals or companies who know the content area."

Inexpensive or free support for teachers integrating software into their practice is frequently available not only from community colleges but also from software providers, Means adds. "A number of multimedia software vendors give special courses to teachers at a low cost because they want teachers to use their product. They realize this support is the pivotal step to get teachers comfortable with the software."

A Research Agenda

What type of research is needed on technology and education? Are there ways in which practitioners can be involved in action research projects that would help the broad research and policy community? Is it realistic to involve practitioners in the research, or should the agenda be executed by others?

"While there are some nice studies that cover a little bit of the landscape," Means responds, "if the landscape is defined in terms of the different developmental levels of students and the different content areas that teachers teach and care about, a large part of the landscape is blank. This is particularly true if we add in variables such as different student cultures, different school settings, and differing teacher orientations. We need to go beyond the question: Does 'it' work?

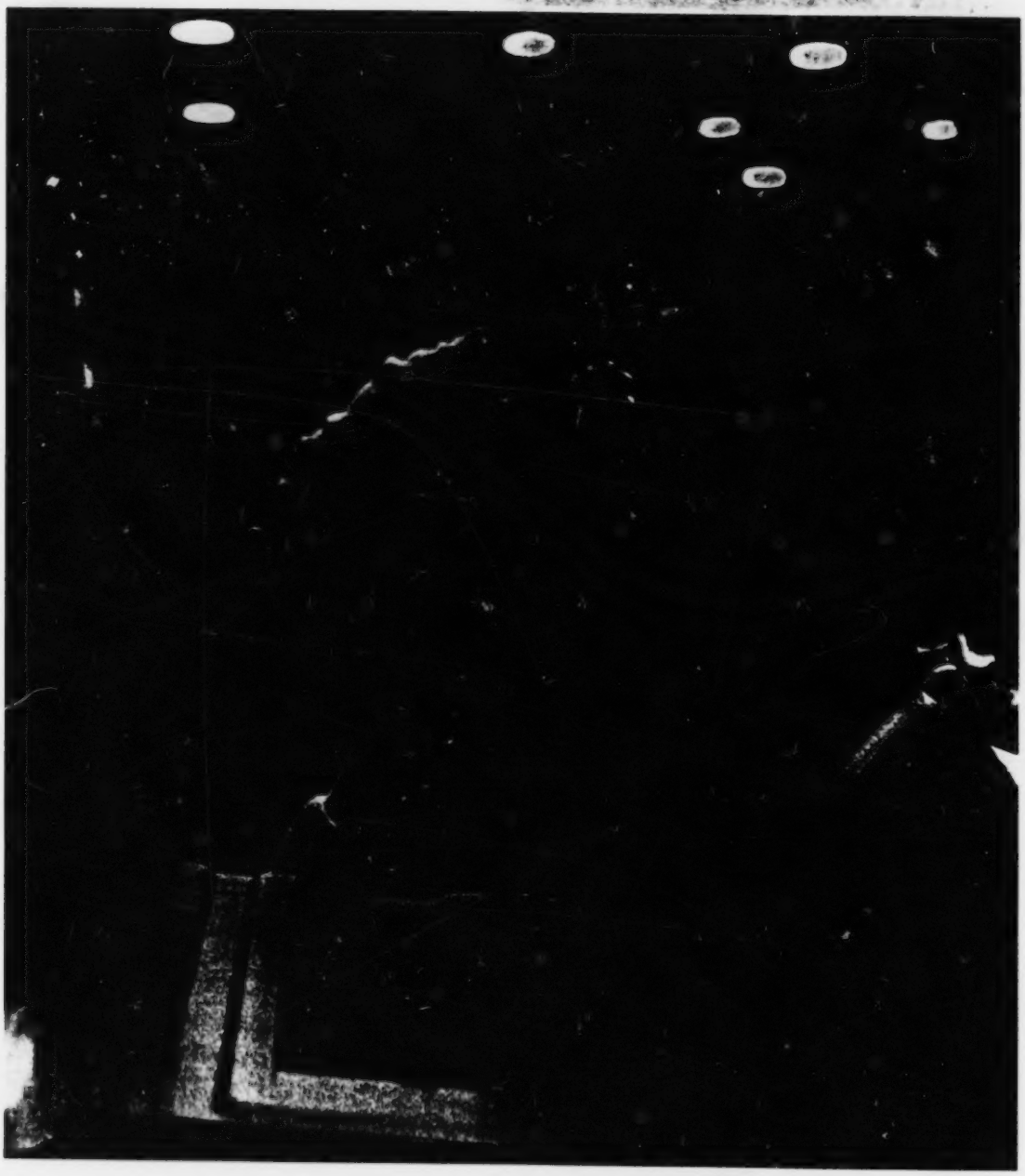
"Instead, we need to build a knowledge base to find out which technology-supported approaches work best for what kinds of learning goals with what kinds of students."

While enthusiasm for technology in education is widespread, this enthusiasm is naive when it remains solely at that level, she believes. "We need to move beyond the purely journalistic," she says, "and realize that objectivity and rigorous methodology are often missing in reports of classroom uses of technology. Both will be necessary to make this research convincing to the world at large. In addition to those, it is just as important for researchers to possess detailed knowledge of the classroom and the school context."

Teachers as researchers could be an exciting possibility, Means believes, but good, solid, and imaginative teaching exerts its own pressures and demands—which could divert from a research agenda. "It is terrifically difficult to do a good job of teaching, and it is also difficult to do a good job of research," she explains. "It is extremely hard to do both at the same time. There have been some genuine teacher/researcher collaborations, often in situations where teachers have some time off from teaching duties to do the kind of reflection and data analysis research requires. I would like to see much more of this."

She continues, "The U.S. Department of Education is currently trying to formulate its research agenda for educational technology. To the extent that teacher voices can be brought together and crystallized," she observes, "there is a real chance for teachers to articulate the issues with which they grapple and where they need strong research evidence."

But she concludes with her deepest concern. "Technology is a cultural icon for us. Whether every student can get on the Internet is not as important as the kinds of experiences students have with the technology when they get there—and these will depend on the instructional frameworks."



"Nothing is so powerful as an idea whose time has come."

Victor Hugo

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Schools or districts interested in incorporating technology into their academic programs are wise if they consider incorporating it as an integral portion of their entire vision for teaching and learning—rather than as two separate and disconnected entities.

Northbrook Middle School: Technology for High-Needs Students

Northbrook Middle School (NMS), located in Houston, Texas, serves a student population of 852: approximately 78 percent Hispanic, 9 percent African American, 6 percent Caucasian, and the remainder Asian and Native American. A high percentage—approximately 80 percent—qualify for free or reduced lunch; approximately 280 students are English language learners and are enrolled in ESL (English as a Second Language) classes as part of their academic program.

Northbrook Middle School embraced technology as a tool to enhance its teaching and learning as part of its complete renaissance and reopening. Closed in the mid-1980s due to declining enrollments, strategic planning and a vibrant academic mission distinguished Northbrook's reemergence on the educational scene. In 1990, Susan Wolf was appointed Northbrook's principal and charged with the mission of creating both a model middle school and a technology demonstration school for the Spring Branch District in Houston. A year of planning preceded the reopening of the school in 1991, with ample amounts of staff development focused on technology as a tool for project-based teaching and learning.

When NMS reopened, it did so with a staff specifically selected to fit the school's mission—a combination of experienced teachers and enthusiastic newcomers. A commitment to the principles of constructivist teaching and learning, a vision for technology as a means to aid in that vision for learning, and a strong emphasis on site-based management have all suffused NMS's ethos and mission.

In addition, the design and appearance of the school were considered integral to furthering its academic vision—with the goal of making it homelike and welcoming for students, parents, and staff. A country theme permeates the school; standard concrete blocks are warmed with wreaths, decorations, and Americana.

Northbrook Middle School's experiences highlight the following principles for school leaders and staff:

- *Site-based management, if infused into the ethos of a school, can ensure that teachers participate in key decisions about both the instructional vision of the school and technology's use to enhance and achieve that vision.*
- *Students help create and produce their own learning; technology serves as both tool and motivator.*
- *Poverty and level of proficiency in English are not viewed as negatives, but as realities with which teachers must work in a positive, proactive manner.*
- *How and why technology is used—to supplement teaching and learning—is much more important than technology itself.*

The spokesperson for Northbrook Middle School is Laura Schuhmann, who was appointed its principal in 1996 following the death of Susan Wolf—a school leader she credits for keen vision, energy, and intelligence. Prior to becoming principal, Schuhmann was assistant principal at NMS and elsewhere in the Houston Independent School District (HISD); earlier in her career she was recruited by the HISD to teach reading, language arts, English, and speech in Houston's inner-city schools.

When Laura Schuhmann describes how technology fits into the educational mission of Northbrook Middle School, she emphasizes with crystalline clarity that technology is not an empty concept or meaningless slogan to the school's teachers, students, and parents. Instead, technology is a lively and carefully crafted portion of Northbrook's entire academic vision—a powerful engine to accelerate active, project-oriented teaching and learning.

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Exactly what is Northbrook's vision? "We want *all* students," Schuhmann emphasizes, "to have the opportunity to be successful. Our expectations for student achievement are very high. And if technology becomes the vehicle that heightens student achievement, then we want to use that vehicle."

She adds, "But we don't use technology just to use technology. We use it as a tool to enhance what goes on in the classroom."

Northbrook Middle School's vision wants to see students taking an active role in their own learning, becoming discoverers of knowledge, and relying upon teachers as coaches to assist them as they explore new frontiers of information. Commonly known as constructivism—teachers and students constructing knowledge together—this view of teaching and learning can present particular problems for teachers either unfamiliar with its concepts or unreceptive to its potential.

What does constructivist theory mean in practice to Northbrook's teachers? How do they interpret it? Are they resistant to its principles? Wary? Enthusiastic?

Schuhmann first explains that viewing learning and teaching in a constructivist, project-oriented manner is essential if technology is to succeed as a tool to further school reform—and its concepts are woven into the fabric of NMS's daily life. "Constructivism," she says, "means that our teachers can give up some of their traditional control of the classroom and allow students individual opportunities for enrichment, for tutorials, or for individualized planning. This may mean that the computers at individual student stations are used; it may mean that the room is divided into teams using a lot of cooperative learning strategies. In that situation, the computer again becomes a tool with which the teacher can enrich, tutor, or provide individualized work with students."

But switching from a conventional view of instruction in which the teacher dispenses information to students—who remain essentially passive—presents its own set of difficulties, she cautions. Schools or districts interested in incorporating technology into their academic programs are wise, she maintains, if they consider incorporating it as an integral portion of their entire vision for teaching and learning—rather than as two separate and disconnected entities.

What main barriers do school staff face when shifting their conventional practice toward project-oriented instruction—and how might these obstacles be overcome?

"Teachers may believe in the principles of constructivism," Schuhmann says thoughtfully, "but it is difficult to give up control. The students may get a little loud; they are not sitting in nice little rows. The question for teachers is: Can they handle that?

"Teachers have told me quite openly that they don't want to give up that control of the classroom without realizing that in some way they will have better control as a result. They struggle with that. But the teachers who do it—and who do it well—are the ones without discipline problems. They are the ones who see their students achieve at significant levels. They are the teachers who have motivated students who are excited to be in their classrooms.

"As a result," she adds, "we see more and more of our teachers trying to do more of that type of teaching—even if they are unable to do it every single day."

Schuhmann observes pragmatically, "It is easier, of course, just to tell the kids what they need to know. But students need a teacher who will facilitate their thinking processes, not just tell them what they need to know."

Technology as a Teaching and Learning Tool

Schuhmann acknowledges that the possibility for computers to turn into nothing more than electronic worksheets—just as didactic as conventional instruction—is a danger that Northbrook's staff guards against both in its daily practice and in its long-range plans. "Although we do have several computer labs," she says, "we also have four or five computers in every classroom, which is a unique situation compared with most schools. In this situation, instructional software selections become critical."

How and where computers are placed and used is critical, Schuhmann maintains. "When we hire new teachers, they typically ask: Where is the computer lab? Our answer is that the tools are right there in every classroom. That is not to say that there are not times when it is appropriate to take an entire class to a lab, but we want teachers to work directly in their classrooms with the principles of constructivism."

Aren't there many ways to further constructivist teaching and learning? Why is technology so important?

To Schuhmann, the answer is simple—but success does hinge on how technology is used. "Kids love it," she says. "In our school, they have the opportunity to do creative things with technology, to explore. In fact,

"Our teachers had a voice in shaping the mission and philosophy of the school. That mission and philosophy is revisited every spring through a campus improvement plan, which is then formulated for the following school year based on data that have been gathered over the past year."

we have students who can teach our teachers about computers. Those students actually act as technology assistants in classrooms—which gives them a real-life opportunity to apply their expertise."

Perhaps the biggest area of improvement, she believes, has been found in student motivation. "Does technology make a difference?" she asks. "We like to believe it does. We believe that in terms of motivation it does.

"Does it have a direct impact on student achievement? Statistically, I am not sure we can prove that at this moment, although we have written a grant proposal to do some research that would result in some definitive statements about technology's impact on student achievement."

But if she is making the case for technology to other school leaders, how might Schuhmann convince them of the rewards? "The opportunity to be on a computer is something that kids love," she says. "Teachers have more freedom in their classrooms if they have computers available because they can work individually with the student who might not be where the other students are—and the rest of the students can be usefully engaged."

The eventual real-world demands of the workplace influence Schuhmann's thinking as well. "As we prepare kids to go out into the world, we realize they have to know something about technology. Using it as a tool accomplishes at least two goals: not only teaching and learning in a constructivist manner but also giving students an opportunity to learn something that will be very valuable to them when they leave school and enter the outside world."

She adds that NMS's use of technology was carefully planned and integrated across content areas. "Students each have an individual account on a file server where work is stored," she explains, "and they access their portfolios by a password. In that way, they can carry what they do with them—and it has real significance in their daily classwork."

To ensure that student use of computers doesn't become haphazard or a waste of valuable learning time, all sixth graders take a course in computer literacy that offers them the basics—a foundation for eventual computer literacy. "Basic computer literacy was a required course by state law for eighth graders," Schuhmann adds, "but we got a waiver so that we could teach it earlier. There is no sense having kids wait until the eighth grade to get that kind of knowledge when there are computers in every classroom. Our technology course offerings also include video technology and emerging technology."

Are teachers and parents concerned about inappropriate use of computers? A strict technology code of ethics applies to student use of computers, she notes, and has been very successful. "We have Internet access on almost all computers. We didn't want to have to put blocks on computers where students couldn't access certain materials, especially since they are working on research projects, so we explain at the beginning of the year that they have a responsibility to make ethical choices where computer use is concerned. Somewhat surprisingly, it hasn't been a large issue."

Structures That Facilitate Technology

Just as Northbrook Middle School uses technology as a tool to aid constructivist teaching and learning, its school structures also accommodate this instructional focus. Schuhmann first points to the changeover from a traditional schedule to an alternate block schedule, in which eight class periods are held over two days. "We don't have a day where all eight periods meet," she explains. "Every child actually has six classes, 90 minutes each, because language arts and math are double-blocked. This means that each child meets the math teacher every day and the language arts teacher every day. Social studies, science, art, and the elective courses are every other day."

Site-based management, in which teachers have a voice in all decisions that affect the school, flourishes at NMS, Schuhmann says. "Many people talk about site-based management, but we live it. Our teachers had a voice in shaping the mission and philosophy of the school. That mission and philosophy is revisited every spring through a campus improvement plan, which is then formulated for the following school year based on data that have been gathered over the past year."

Other formal and informal procedures are in place to ensure adequate teacher participation in decisions, particularly about technology, which is not consigned to the purview of a select group of "experts." As Schuhmann explains, an eclectic campus advisory team consisting of parents, teachers, and community members meets monthly to make sure the campus improvement plan is implemented.

"The teachers on the campus advisory team," she notes, "form our Operations Committee, which meets weekly and is open to all faculty. The agenda is open to all who participate, and anything can be placed on it, with the exceptions of budget and personnel. This meeting gives all teachers an opportunity to put anything on the table that is bothering them, that they believe needs improvement."

A separate weekly faculty meeting is devoted to staff development issues, she continues, and a technology committee also meets weekly. "Every department and every team in the school is represented on that committee," she emphasizes. "We have an instructional facilitator for technology who chairs the committee; technology decisions from software to budgeting considerations to staff development for technology go through that committee."

Technology permeates informal and formal staff communication as well. "All of our communication is done by e-mail in the building," she says, "and minutes of every meeting are published over e-mail. Weekly e-mail bulletins remind people of meetings. This communication structure supports our efforts very effectively."

Schuhmann believes that the management structure—participatory, collaborative, yet organized—is the engine that drives the application of NMS's vision. "This structure allows teachers to be empowered, to have the opportunity to be creative, to be innovative, to try new things, and also work within an open and very well-informed environment."

With so many innovations, has teacher support ever wavered? Because the staff was carefully selected at the outset, have they bought into every new idea and concept—or have they balked as changes continue to accrue?

"There are obstacles," Schuhmann acknowledges. "We have trouble finding the time for adequate staff development opportunities for teachers. Our teachers are very willing to do many things on their own time and to do what is best for students in this kind of environment where student needs are greater than average."

But proficiency in technology—coupled with the ability to use it imaginatively and appropriately in the classroom—requires considerable time and commitment, she emphasizes. "We do offer staff development before school, after school, during the school day, on conference days, during team planning, and on regular staff development days. But that is still not enough.

"We have teachers at various levels of technological proficiency. Some are extremely oriented to technology and others aren't at all. Of course, we try to get everybody to a certain level—and for the most part they are—but we have a group of new teachers this year who are in the beginning stages."

However, being a technological beginner is not a barrier to pedagogical success, Schuhmann insists. "When we hire teachers, we tell them they don't have to know much about technology—but they have to be willing to learn. And even seven years after the school opened, they still give us unpaid time before school starts to learn some of the basics so that they can handle their administrative responsibilities on the computer, such as grades and attendance."

If technological expertise is not a screening device for prospective staff, what qualities and characteristics does Northbrook seek? The needs of Northbrook's students—a high percentage of whom are English language learners and come from

"This structure allows teachers to be empowered, to have the opportunity to be creative, to be innovative, to try new things, and also work within an open and very well-informed environment."

poverty—guide both teacher selection and long-range planning. "We have focused a great deal on Ruby Payne's book, *Poverty*, and Martin Haberman's book, *Star Teachers With Children In Poverty*. We have used Payne's book as a model for instructional practices.

"We tell prospective teachers up front that this is not an easy place to work. Our kids are very needy. They like coming to school. Our attendance rate is very, very high. Our scores on the Texas Assessment of Academic Skills are above the state average. Our kids feel safe here, they like being here, and it is a pretty school."

"We offer computer classes for parents at night, and we focus on some basic skills such as resume writing and computer literacy. We teach these classes bilingually to meet the needs of our parent population.

Developing Technological Competence for Teachers and Parents

When teachers' technological expertise varies, how does NMS build in safeguards to ensure that everyone is using technology appropriately—in tandem with the goals of constructivist teaching and learning? "In our district," Schuhmann responds, "we spent a year formulating our own appraisal process and have recently put together a list of competencies for teachers in technology. This list was based on what we have always done at Northbrook Middle School."

At Northbrook, she adds, teachers have maintained an individual technology plan in which they share their own assessments of individual competencies along with areas in which they need to grow. "The new appraisal process," she notes, "includes goals that teachers will set for themselves in terms of technology."

The proficiencies range from the most basic items such as turning a computer off and on; understanding the terms "file," "folder," and "application"; to problem solving and collaborative concepts via technology in the classroom. "These are obviously the most sophisticated proficiencies," Schuhmann notes.

"Each area includes competencies that a teacher should be able to handle."

Will these competencies be used as part of teacher evaluations? What will ensure that they will be met?

"Since this is the first year," Schuhmann responds, "everybody is supposed to meet certain goals that are individually set. Across the district, the plan is for technology to be part of the discussion but not a requirement in terms of the goals. Eventually meeting these goals will be a requirement, however.

"We wrote into our school improvement plan that each teacher will write one goal as it relates to their use of technology."

Northbrook Middle School works proactively with parents to include them in the technological process—thus trying to diminish any apprehension about computers that they may carry with them because of unfamiliarity. "We offer computer classes for parents at night," Schuhmann says, "and we focus on some basic skills such as resumé writing and computer literacy. We teach these classes bilingually to meet the needs of our parent population.

"Since they don't have computers at home, we began collecting old computers from warehouses, donations, and surplus computers from the district. We refurbished them and set up an incentive for parents to attend these evening computer classes. If they attend four sessions and bring their child with them, they take the computer home with them. As long as their child remains in the school district, they have use of that computer."

While these computers are not sophisticated and lack Internet access, they are capable of basic word processing, Schuhmann points out, and allow parents the opportunity to work on resumés or other basics—such as spreadsheets and databases—that might help them in their daily lives. In this way, she believes, a cycle of learning continues from the school to the home, and has direct benefits to entire families rather than students alone.

Given that NMS reopened with a charge to become a model school for technology, did it receive a special infusion of resources to support that charge? Are there ongoing financial challenges that NMS faces as it works to keep its technology current?

"The renovation of the building," Schuhmann says, "was done through bond money, and the renovation was not just for technology. The building had to be heavily rewired, of course, and the original allocation for hardware and software combined was approximately half a million dollars."

But staying current is an ongoing challenge for all school leaders, she believes. "We now face the fact that much of our original equipment is obsolete. Obviously, all school districts need to make an original investment and an ongoing investment in their technology. School boards and district personnel need to remember that eventually things do break down and have to be repaired or replaced. I have heard of schools where computers break down and are not repaired. We are fortunate that we are not in that situation."

A creative use of Title I funds helps NMS with its ongoing investment in technology, she points out. "We have a fairly considerable technology budget, which allows us to do some upgrading annually, but we also are a complete Title I school. Every year a large portion of our Title I monies are devoted to technology. This has kept us moving ahead."

But even that resource is not sufficient, she argues, and staying current will require an entrepreneurial spirit on the part of all school staff. "We are looking at options such as grants and donations. Other schools have PTAs with great fundraising capabilities, but we do not have parents with that kind of money. We have to rely on public sources of money through grants. We always hope for more money, and the district's investment in technology has been substantial."

This commitment, she says, is tangible and real to each teacher at NMS. "We have a computer for every teacher, which is again not typical of many schools."

Judicious, informed decisions about how best to allocate resources for technology are also critical, Schuhmann adds. "We have many, many visitors from other schools. They tend to believe that if they have the money for 30 computers, they need to set those computers up in a lab. In some situations that might be the right thing to do, but the question one has to ask is this: What do you want to do with the technology? What is the point of having it?"

At NMS, one computer lab exists solely for word processing, spreadsheet, database, and graphics—but no multimedia capabilities. "These computers can't handle more advanced sorts of things, such as CD-ROMs. However, if a language arts class wants to have kids write and polish their drafts, the lab is used for that purpose," Schuhmann explains. "We have another lab solely of Power Macs, all multimedia capable, and that also has specific purposes."

But she returns to the central question, which she argues must guide all thinking, discussions, and decisions: How will technology be used and to what ends? "Everyone says technology makes a huge difference, but how do we know it does? We see it in the overall environment of our school; we believe it contributes to motivation, increased student achievement, and discipline issues.

"But," she concludes, "is technology the direct pathway that makes all of that happen? That is the question we have to face and we have to answer."

"Everyone says technology makes a huge difference, but how do we know it does? We see it in the overall environment of our school; we believe it contributes to motivation, increased student achievement, and discipline issues."

Community High School: Schoolwide Technology and Project-Oriented Learning

Community High School (CHS), an alternative high school within the Ann Arbor Public Schools in Ann Arbor, Michigan, has a long history of innovations in education. Now in its 26th year, CHS's original mission was to use the community as a classroom. Students were expected to earn credits through various projects and work in the community, e.g., internships, apprenticeships, or coursework at the University of Michigan. No classes were taught within the building; teachers served as monitors to ensure that credits students earned would meet state requirements for graduation.

Currently, CHS teaches most classes within school walls—but continues to emphasize the community as a primary resource. In fact, Community Resource classes compose an entire department within the school. Since CHS is located in the downtown section of Ann Arbor, it is within walking distance of the University of Michigan, libraries, museums, and shops—all of which serve as extended classrooms for its students.

Any high school student in Ann Arbor is eligible for admission to CHS—admission is determined by lottery—but over the years, a waiting list has grown. Today, CHS holds 400 students, approximately 19 percent minority, including African American, Asian, and Pacific-West Islanders.

Community High School's science department led the wave of teachers who began to believe that technology had the potential to help change instruction to a project-based approach. CHS's science teachers, with an infusion of resources and expertise from both the University of Michigan and the National Science Foundation, transformed its science curriculum into an innovative program that relies on real-world applications of concepts and scientific theory.

From the original technological infusion into its science program, technology now spreads across content areas throughout CHS—and an evergrowing emphasis is placed on project-oriented teaching and learning. To accommodate this new emphasis, school structures also continue to be refined to fit CHS's new vision of learning.

Community High School's experiences with both project-based teaching and learning and its integration of technology throughout the school highlight key lessons for school leaders and staff:

- *School staff view technology as a tool, not as a separate content area.*
- *While technology is infused into most content areas, it is secondary to a vision of learning that emphasizes student- and teacher-created learning.*
- *Imagination and collaboration can result in mutually beneficial partnerships between universities, federal research agencies, and public schools.*
- *School structures are flexible and require continuous, judicious refinement to accommodate growth in the school's vision of learning.*

The spokesperson for Community High School is Judy Conger, who has been its dean for four years. She has 20 years of educational experience, the last nine of which have been in the Ann Arbor Public Schools. Prior to her position at CHS, she served as assistant principal at Pioneer High School and held a variety of teaching positions.

A student-developed product that is received by an eager audience—Community High School's weekly newspaper, *The Communicator*—vividly illustrates the ways in which technology has integrated itself into the school's emphasis on project-oriented teaching and learning. Produced as part of a popular class, *The Communicator* has an enviable role: It serves as both student motivator and authentic student product.

Not only does this newspaper provide students with an authentic reason to learn, apply, and refine their use of technology, but it also forms the structure through which they experience real-life deadline pressure, collaborative work among peers, and development of ideas.

Judy Conger points to this newspaper as one example of CHS's goals—both its vision of learning, which is proactive and project-based, and its effective interweaving of technology into real-life applications of what students learn. The enormous interest that the eight-page newspaper generates each week is one key to its success, she reports.

"When it is published each week, everything stops in its tracks," she says. "Kids are sitting all over the place immersed in it; teachers are reading it as well. It receives this intense attention because it is a very lively and interesting piece of work."

The technology used to produce the newspaper is sophisticated and well-planned, as is the structured—and necessary—collaboration between students. "A laptop computer goes home with the editor each week—and the editor rotates each week," she explains. "Students post their stories in the computer lab and send them via e-mail to the editor, who assembles them. Finally, the actual newspaper is run on PageMaker, taken to an outside printer, and distributed throughout the school each Wednesday."

How Technology Assists Project-Oriented Teaching and Learning

The school newspaper, however, is not the only way in which CHS students create their own learning with teachers working alongside them as coaches and facilitators. In fact, the entire school's instructional focus-has shifted in recent years to a constructivist, project-based vision of teaching and learning.

To what does Conger attribute the apparent success of the school's instructional vision—and its integration of technology as a potent tool to further its aims? To begin with, she credits teachers for their willingness to stretch the frontiers of their knowledge in a variety of ways.

"A school like ours attracts teachers who are on the cutting edge of their practice," she points out, "and as technology has gained a stronghold in the United States, these are teachers who would use technology for themselves. At our school, they bring it into their classrooms; they look for opportunities to use it; they search for equipment; and they apply for grants and partnerships."

This entrepreneurial spirit—combined with technological and content expertise—is not necessarily typical of other schools, Conger acknowledges, but she sees it as the fuel that fires many of CHS's innovations. Added bonuses are the school's size and collegiality as well as its continuous refinement of existing structures.

"Our school is different from others in that it is small," Conger points out. "People have a lot of contact with each other on a regular basis. One teacher will show another something he or she is doing and that teacher will start to think about how to use it or something similar. Because teachers can easily discuss and demonstrate ideas with each other, there is a snowball effect that results."

Conger emphasizes that this type of easy, ongoing collegiality cannot be mandated—although school leaders can and should nurture and safeguard its presence. She adds, "The ways in which we have used technology to supplement teaching and learning have certainly not been forced by the administration. Instead, the teachers have led the vanguard."

Structures to Accommodate Technology and Project-Oriented Learning

But even armed with significant teacher collegiality and enthusiasm, CHS has found it necessary to refine its school vision—and fine-tune structural changes. This refinement is exemplified, Conger believes, by the work of science teachers who began an initiative in 1991 to reform CHS's entire science curriculum—changing it to a project-based, carefully constructed experience. This shift, she reflects, led to a broader press to change the entire structure of the school in the belief that the time devoted to instruction would not only increase, but improve in quality.

"These teachers were the forerunners," she adds, "who pushed for the machinery, the wiring, the Internet access, and the whole vision of technology as a tool that could help us achieve our reform goals."

Working with the University of Michigan and the National Science Foundation (NSF), these science teachers became an integral part of a massive collaboration that provided necessary resources and considerable expertise. "The project infused hundreds of thousands of dollars of equipment, technology, and expertise into our building over the years," Conger explains. "As part of our partnership, the University of Michigan bought half the laptops used in the project and our school district bought the other half."

To ensure that all students in the project would have equitable access to computers, laptops were purchased for entering freshmen in quantities to guarantee two students to one laptop. "Students alternated nights that they could take the laptop home. Each

"The ways in which we have used technology to supplement teaching and learning have certainly not been forced by the administration. Instead, the teachers have led the vanguard."

successive year of the project, additional laptops were purchased to accommodate the number of incoming freshmen. This continued for four years. Just in our science classes alone, we have 150 laptops for 300 students, plus a computer lab with 25 computers in it and various other machines throughout the building. Our goal is to have one computer per classroom, primarily for teachers, but students may use them also."

Refining School Structures to Support Project-Based Learning

Because their experiences with project-based science were so successful, the same science teachers, Conger adds, led the impetus to transform the entire school's curriculum—with a focus on integrating technology into all content areas wherever possible. As a result, during the academic year 1996-97, CHS adopted block scheduling in an attempt to encourage project-based teaching and learning—an innovation not greeted with equal enthusiasm by all school staff.

Confronted with different divisions of instructional time, some staff balked. "This is typical of any school that has gone to a block schedule," Conger says in a matter-of-fact tone. "Before we moved to the block schedule, staff who resisted it were concerned about fewer total minutes per week for each content area, whether the attention span of middle school students matched the schedule, and the loss of coverage of material.

"But we would never have gone to block scheduling without large staff support," she adds. "When we had over 75 percent of our staff on board, we moved to it. Currently, I would estimate that we have 90 percent staff support."

Even the implementation of block scheduling, however, was flexible. Conger observes, "In some cases, the structure came after the vision. In other words, after the curriculum changed, the block scheduling came next. In other cases, the blocks came first and teachers found ways in which to use them creatively."

Educating Parents and Families

As CHS changed its instructional focus and infused technology into different content areas, how did it ensure that parents would understand their efforts and lend their support? To what extent are parents and families included in CHS's instructional goals and its multipronged emphasis on technology? Conger believes that families must be educated as aggressively as students, or the goals of both project-based learning and technology may suffer.

"On our annual curriculum night, we begin with a run-through of each child's schedule for the parents," she explains. "They meet ahead of time with our Foundation of Science staff who talk about programs, the computers they are going to use, and what it will mean for students. They learn how their children will bring computers home and will learn to use the Internet.

"This generates tremendous enthusiasm and buy-in from families," she adds. "Parents begin to notice that their kids not only bring home these computers, but they do other homework on them too—which we encourage them to do. Just as school districts have to push past some initial teacher resistance to technology, our teachers try to overcome some parent resistance to technology. Our district offers workshops for families; teachers spend a lot of time talking to parents about the technology and how their kids use it."

Once initial reservations—even fear—are overcome, parents' enthusiasm increases as their children start to teach them different computer skills at home. "We try to use technology throughout the school, not only in our newspaper, which is another student product that families can see being created at home, but also in our library and media center and in other content areas.

"For example, our social studies program works on another project with a professor at the University of Michigan, and social studies classes are learning how to use census data, which is provided on disk. These classes do a lot of conferencing and have considerable Internet access too." But this access, she emphasizes, is not random and haphazard, but structured and purposeful.

"Students download data sets and the most current information, and then work with that information," she adds. "In some ways, technology is such a part of our school that we don't think about it except in terms of the new ways in which we can access information and improve student learning."

In CHS's foreign language program, teachers are finding a use for some of the school's oldest computers—hooking them to the Internet so that their students can correspond with French and Spanish penpals in "real time." Math and physics have also been affected by technology, she points out. "Math classes use geometry and algebra software programs, and our physics classes use an interactive program for physics models."

Even CHS's music program benefits from technology, she points out. "We have a jazz program that is nationally and internationally renowned. For the past seven years, students have participated in the North Sea Jazz Festival in Iceland. Every year they make a CD of their production, which is a very high-tech way to work with their music. They use computerized keyboards and software to write their music, record it, and play it."

Just as CHS's science teachers were in the vanguard for technology, its students now are equal partners in leading the charge, she says. "We listen to student ideas. Being small and

being an alternative school we tend to be light on bureaucracy," she notes, "and we take advantage of whoever and whatever comes our way—using these resources to catapult our information base."

When a school becomes this technology-dependent, are there any negatives? Aside from mechanical problems that can occur, Conger believes that careful district and school-level planning ward off obvious pitfalls, such as out-of-date equipment or unused computers. "The large buildings in the district each have a computer specialist," she says, "and the small buildings such as ours share one with another building. If something is down, these specialists are only a phone call away, so that everything doesn't depend on one teacher who has only one release period and who usually doesn't know much about repair."

Planning and Budgeting for Technology

As CHS made curricular and structural changes, how did they make decisions about how much money to spend on computers, where to place the machines, and other pragmatic considerations?

"In the past, we had one teacher whose assignment was to be the computer coordinator. That person," Conger explains, "spearheads the committee, becomes knowledgeable about technology, and attends district meetings with me. We then made our decisions based on who already has what, who did what, what department has what, and who can share.

"This year," she continues, "we don't have that one teacher. We have two nonteachers assigned to our building in a new districtwide structure of hiring technology specialists and assistants."

Obtaining sufficient resources to support CHS's ambitious technology infusion into different content areas hasn't been difficult, she adds, because a successful bond issue in Ann Arbor resulted in a five-year implementation plan. "The first year, we received a dozen computers. In a building of this size, a dozen computers isn't bad. They can be divided up by departments and be shared.

"As the next step, we will receive a television and VCR for each classroom, along with a second wave of computers and printers."

If staff jealousies over hardware and software develop—as they can in any school—Conger puts the responsibility on individual teachers to search out additional resources. "If a teacher doesn't choose to be part of a project that results in additional computers for the school but still wants access to them, that is not part of the deal," she says firmly. "If somebody wants to find a partnership, they are free to pursue one and probably will succeed."

And for families who do not own computers—including those who cannot afford to buy one? "We began a purchase program through which the Ann Arbor Public Schools would enact an arrangement through one of the local banks. The idea was that parents could borrow money at a very low interest rate for a laptop or computer for their home use and the Ann Arbor Public Schools would guarantee the loan. This would have been affordable to all families, but although we made significant progress on the plan, we didn't enact it."

Guidelines for Other Schools

What guidelines does Conger suggest for schools that may not be able to embark upon university and federal partnerships? Or for schools without a concrete sense of where to begin?

"Find your gurus and nurture them," she responds immediately. "Recently I was reading a publication of the Educational Testing Service that focused on ten lessons every educator should know about technology in the classroom. I found their suggestions especially pertinent. They recommend that schools isolate their key learning goals and build a team. They suggest that school staff think of technology as a tool, not a subject. But the tip that I found the most interesting was to find your gurus and nurture them.

"Finding gurus," she emphasizes, translates easily into identifying the lone "technophile" in every school who believes in the potential of technology to change the face of teaching and learning. "Every school has at least one technophile who is an early believer, who buys into the potential of technology before others. You begin with the ones in your building who are enthusiastic and know a great deal, and then you find those who don't know much but are curious and aren't afraid to learn. When they actually start using technology, whether it is keeping a database on their class or working on actual projects with kids, their excitement will spread to other teachers."

Even teachers bound to a traditional approach can incorporate technology and be won over by its benefits, she adds. "We have an English teacher who is a national award winner," she says, "and very traditional in her approach. She emphasized writing, writing, and more writing. Now she is hooked on technology. Her students now write their papers in much the same way that the newspaper operates, using the machines and the printers."

To Conger, this story exemplifies the best practice of technology. "While this teacher is not a technophile," she emphasizes, "she is very excited about everything she learns and passes that excitement on to her students. She is a regular person who is learning one new thing after another."

"I like the dreams of the future better than the history of the past."

Thomas Jefferson

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The Glen Ellyn School District: Implementing a District's Technology Plan

Located approximately 25 miles west of downtown Chicago, the Glen Ellyn School District serves approximately 3,100 students, grades K-8. Although for the most part its student population typifies many suburban districts—primarily white and middle-class—in recent years it has become more diverse and now includes students from lower-income households.

Its funding, however, does not match the relatively prosperous status of its students. At approximately 10 percent below the state average per child, Glen Ellyn's funding was affected by an Illinois state tax cap enacted in 1990. This funding level affects all expenditures, which becomes especially critical at a time when school districts are investing heavily in technology. Glen Ellyn's successful referendum in February 1997 provided the funds to put the necessary infrastructure in place in all its school buildings so that technology can infuse everyday school life as a multifaceted tool, both for school staff and for students.

The spokesperson for the Glen Ellyn School district is its Superintendent, Pi A. Irwin, who has brought the district online with an ambitious and meticulously crafted plan to integrate technology into the district's curriculum and instruction. In particular, she has built partnerships with local institutions of higher education, including Northern Illinois University and the College of DuPage, a local community college. A strong partnership with the North Central Regional Educational Laboratory provides additional expertise.

Irwin believes that significant community input on the placement and use of technology in the district's schools also helps steer the district's passage as it anchors technology into the district's overall vision for constructivist teaching and learning.

The Glen Ellyn District's work to integrate technology throughout its K-8 curriculum highlights broad lessons for other districts:

- *Build authentic partnerships wherever possible, particularly with local and regional institutions of higher education, regional educational laboratories, and city and county government.*
- *Develop an action plan with timelines while seeking additional resources to fund an ongoing investment in technology.*
- *Invest at least one-third of a district's budget into training for school staff; this investment is imperative and must be viewed as an integral part of any technological investment.*
- *Nurture those staff who are supportive of a vision for technology; this leads to the development of a critical mass of school staff who will push the innovation forward.*

Irwin has been superintendent of the Glen Ellyn Elementary Schools since 1993. Previously, she was assistant superintendent of the Tucson Unified School District in Tucson, Arizona, and also held a variety of administrative positions—including principalships at the elementary, middle, and high school levels—in that district. She holds an Ed.D. in Reading and Educational Administration from the University of Arizona.

If Pi Irwin were charged with the task of convincing other school leaders that technology can increase student achievement and engagement, help bond students to school, and also advance an ambitious agenda for learning, she wouldn't hesitate to take on the challenge. Why is technology necessary—especially when research that demonstrates its positive effects on student achievement is skimpy or in the fledgling stages?

Irwin's reasoning is clearcut and logical: Educators, she says, need to come to terms with the relevance of technology to virtually

Irwin's reasoning is clearcut and logical: Educators, she says, need to come to terms with the relevance of technology to virtually every aspect of contemporary American society—and this relevance also affects rapidly changing expectations of students.

every aspect of contemporary American society—and this relevance also affects rapidly changing expectations of students.

"Just as technology is a way of life in the community," she begins, "it must be a way of life in the schools. If we are serious about making instruction relevant to students' experiences—and if we want to prepare students to live and work in the world—we have to be serious and strategic about what we do with technology in education."

She mentions a recent incident in which she observed a small child in a large discount store using a computer screen to find locations throughout the store. "There is an example of relevance," she points out.

"Technology is critical because it changes the access to information. Suddenly this access to information occurs in real time—not in school time."

Irwin also emphasizes how expectations of students are changing dramatically as the nation races toward the millennium and technology increases in contemporary society at almost an exponential rate. "We used to think of a good student," she notes, "as one who could do very good recitation, who could memorize, who knew facts, and who could demonstrate orally what they knew.

"Now we expect a good student to have the ability to think and to solve problems. Technology is critical because it changes the access to information. Suddenly this access to information occurs in real time—not in school time."

She illustrates her argument by pointing to a mainstay of American popular culture: Television quiz shows. Just as contestants on quiz shows of the 1950s and 1960s were distinguished by the number of facts they knew, Irwin predicts the quiz shows of tomorrow will shift to a focus on rapid-fire problem solving. "Technology not only becomes the tool that provides quick access to information," she observes, "but it also requires incredible relational thinking skills—and these skills will become the skills that we value and need as a society."

Beginning Steps for One District

But integrating technology into any district—and effectively interweaving it into how and what students learn—is no simple task. Constraints of limited resources, resistance or fear, and sheer unfamiliarity with the ways in which technology can power constructivist teaching and learning can all be significant obstacles.

When Irwin remembers her arrival in the Glen Ellyn district, she recollects that she was jarred by its technological status. "I didn't have a computer," she recollects, "and that was my first purchase."

However, Irwin arrived in the Glen Ellyn district with considerable experience directly related to how a district proceeds with a vision for technology integration into its curriculum. In her previous position as Assistant Superintendent of the Tucson Unified School District, she had participated in a successful $400 million referendum—$40 million of which was earmarked for technology.

"I had the opportunity," she says, "to learn a great deal. We piloted four different systems for elementary schools. As a result, we decided not to go with a canned program from one of the software companies but to work from a more integrated approach. That meant we bought a variety of software—and were able to assess which software was most effective for different content areas."

Insisting on integration of software into the curriculum is one key lesson for a district, Irwin maintains, but she credits one lesson above others from her Tucson experience: The placement of computers in schools can affect significantly how they are used. "We didn't have the funds to put technology directly in the classroom," she says, "so we used computer labs. Every Friday morning I would visit some of our 104 schools. In my visits, I was disturbed that in some instances the labs were really used and in some instances they weren't—

"Using a community committee for technology took us out of a situation where everybody could throw stones at us because we weren't moving forward. It also empowered a whole group of people who were pushing for movement."

even though there was an instructional technology aide in every lab."

These experiences, she says, influenced how she approached the Glen Ellyn District's fledgling technological status—and its obvious need to incorporate technology as an integral part of its educational plan and mission.

The first year she was in the district, Irwin reports she simply could not find funds for technology. "I also had two board members who were skeptical of technology in schools, believing that if it were present, students would not learn basic facts."

An entrepreneurial spirit influenced her next decisions: partner where possible to obtain additional expertise and begin a budgeting process for technology. "I began working with Dennis Gooler, who now is Director of Programs and Services at NCREL. At that time he was at Northern Illinois University. We had an existing relationship with NIU, primarily for student teaching."

She also found a federal grant—and knew that NIU was willing to apply for it as a partner with the district—but quickly realized the district would not qualify because of its racial, ethnic, and economic composition. This experience, Irwin believes, highlights an additional lesson: Additional resources are not always the most pressing need at the outset.

"Instead of applying for a grant, Dennis helped us conceptualize a plan, and it was a plan that we could afford. Our first step was hiring a paid student intern from NIU from its instructional technology program."

That person, Irwin reports, "jumpstarted our program and provided the expertise we needed to start moving forward. We are now in our third year using NIU interns in instructional technology. Our PTAs and principals became involved; through PTA fundraisers we have been able to place a computer in every classroom in the elementary schools."

But the sheer presence of technology—schools bristling with hardware and software—is by no means the ultimate goal, she quickly clarifies. Instead, Glen Ellyn's plan focused on fine-tuning its curriculum and finding ways in which the integration of technology could spur student and teacher engagement.

"We focused simultaneously on examining our curriculum adoptions to include technology," she explains. "Our board now sets aside a percentage of money that is expended solely on equipment for technology. We also know that a third of the money we spend on technology must go for training and professional development."

Irwin's plan was influenced by a positive—and visionary—attitude. "There is a saying that the best way to predict the future is to create it," she reflects. "We had to move forward but we were almost paralyzed due to our financial situation. By involving the community and reaching for resources, it allowed us to be on the cutting edge in many ways."

Actively seeking and maintaining solid partnerships is particularly critical to any district's success in managing innovations, she believes. Currently, the district maintains active partnerships with Northern Illinois University and the North Central Regional Educational Laboratory. It also has developed an institutional network that will link the College of DuPage—the local community college—with the library and park districts, the village of Glen Ellyn, and the three other local school districts. The College of DuPage, Irwin explains, will function as the hub of the collaboration.

"Each one of us needs to look around for help," Irwin says pragmatically, "and we simply have to start. At some point, we have to go for it. And if we had remained insular, we wouldn't have been able to move forward."

Community involvement, although not always solicited by school staff, also must be considered as a central portion of any district's technology planning, Irwin believes. "We established a technology committee in 1995 that was primarily composed of individuals from the community. That has given us great leverage.

"One of those individuals is now on our board. Using a community committee for technology took us out of a situation where everybody could throw stones at us because we weren't moving forward. It also empowered a whole group of people who were pushing for movement."

Overcoming Resistance and Reluctance

What about resistance from staff who question the merits of technology? How has the district worked not only to motivate school staff to use technology as a key component of their instruction but also to increase their knowledge base?

In her reply, Irwin credits one building principal who was especially effective. "I was very fortunate," she says, "because I had one principal who was really pushing for technology in the schools. In addition to his enthusiasm for it, his PTA raised a good deal of money. In a sense, that school is ahead of the others simply in terms of the equipment that they have been able to acquire. I supported him, because I knew that we needed to see that we could all be empowered—and other people came along.

"Any reluctance, at least with our principals," she adds, "was a result of bad experiences with other initiatives. They were unsure that all of this could really happen.

"We were also fortunate to have teachers who were willing to apply to 'try' to integrate technology into their instructional program. In return, they received a multimedia station and training from NIU and NCREL. We do realize that we have teachers who are going to be somewhat reluctant, and we are prepared to deal with that."

Developing a Knowledge Base for Teachers

Part of making sure that teachers will embrace technology and make it a key part of their classrooms means that both their knowledge and comfort level need to be accommodated. What kind of knowledge base is necessary for school staff when beginning to use technology in their classrooms? What skills and expertise must they have to integrate technology into their practice—and not view it as a cumbersome, external appendage?

"Certainly," Irwin responds, "they need a basic knowledge of word processing and an understanding of databases. But it is not enough to have that knowledge unless it is connected with how you will use it."

This connection, she emphasizes, is a key part of the staff training that the district has begun in the fall of 1997. "Our training consists of the basics but it also supports people so that they can use a reading adoption or a math adoption that integrates a component of technology."

She thinks training is as essential to teachers as learning how to drive—with similar components. "When one learns to drive, it is necessary to learn the basics—but you also need a purpose for driving. You need to know how to navigate where you want to go. All of this has to connect with the mechanics of turning on the motor and pushing down the accelerator."

The district's training has been planned carefully to allow all of these components to come together in a synergistic force, she says. "By the end of the 1997-98 school year, we want all teachers to know the basics. Teachers who participated in initial pilots in which they integrated technology into their instruction will be our trainers. They will go into the schools and work with teachers in small groups, out of the classroom, so they can really concentrate. At each school two to three teachers who are trainers will be resources for ongoing support.

"Although," she continues, "we are not wired yet for Internet access in every classroom, there is some access to other kinds of technology. Teachers definitely need to know the basics so they can move on to implement the reading and math adoptions."

Ensuring Equitable Access to Technology for Teachers and Students

Although Glen Ellyn is not as racially, ethnically, and economically diverse as other communities, it nonetheless needs to consider strategies—as do other districts—to ensure that student access to technology does not become inequitable. Are there ways in which the district can construct safeguards for students who do not have computers at home—and who might fall behind their peers as a result?

Irwin points again to the importance of community support and the creative use of available resources. "It is important to work with the community and make sure that in public places such as the library, there is adequate computer access for students and parents. We also need to consider opening up our own school buildings at night.

"In some of our lower-income areas we have set up partnerships with the county so that students can go to a place within their apartment complexes at night and get onto computers to do their homework or other school projects. Some of our student teachers work at night with children in these areas as well."

While community support and creative ways in which computers can become part of public places constitute one strong strategy, there is also a need for a longer-term plan, Irwin argues. "We need to have technology that can be rented or distributed for students to take home," she emphasizes. "I could envision making a laptop available to every child that they could check out for home use, just as they would check a book out of the school library."

To lay the foundation for such a plan, the 1997-1998 school year marks the first year that the district is charging a $25 technology fee per child. "We have children on waivers who can't pay the fee," Irwin notes, "but we are still at the base level of getting more equipment into the classroom. Long-term, a fee such as this could go towards a rental program."

How Technology Is Used

Although any district that works to integrate technology into its educational programs is confronted with a myriad of fiscal and human resource issues, it is especially critical that school leaders not lose sight of the purpose of technology, Irwin emphasizes. She, like other school leaders, believes technology is a tool that can be used to transform traditional, teacher-centered instruction into an active teaching process in which students construct their own learning.

Yet there are obstacles that must be overcome, she acknowledges. "The main barriers," she reflects, "revolve around the fact that it is a markedly different way to teach. We also have a communication problem with parents in that project-oriented instruction looks different to them—and it is not the way in which they were taught. It is not as clear-cut as teaching the basics, whatever those basics are. There is also a strong parental belief that it is imperative to teach the basics."

This debate can be seen clearly in the current controversy over whole language instruction versus phonics, she says. "We need it all," she adds. "Children need to use phonics to have automatic or close to automatic word recognition, but they also need to read for meaning. This is an illustration that as we embark upon project-oriented instruction, there are ways to manage it, ways to monitor progress, and ways to communicate actual achievement to parents."

Lessons for School Leaders

Looking at the broad picture of technology as a tool to support project-oriented learning, Irwin has some final thoughts for other school leaders. "Avoid getting into religious wars," she emphasizes, "such as Macintosh versus DOS-based computers.

"In Tucson, we had that war. Our administrative system was DOS-based; the instructional system was Macintosh. The result was a real war. In this district, we moved to a dual platform and will not get into that war. Of course, it is easier now because software is more and more usable on both platforms.

"The other war to avoid," she adds, "is the debate over basic skills versus technology. Again, that is not a real war. To use technology, you have to know the basic skills."

She ends with her own reflections. "As quickly as we would like to move forward with technology in our schools, we need to realize we are on a journey. None of us knows how that is going to end. There will be trends and downsides of technology that none of us can see.

"If we look at the automobile," she concludes, "we realize now what a revolutionary experience that was for so many people. The positive part is that we can go places and have all kinds of access. But there are consequences: deaths on the highway, congestion, and environmental concerns. I predict we will be faced with concerns as technology develops and these will become a part of our societal fabric. But," she emphasizes, "we will find ways in which to cope with problems as they develop."

"We also have a communication problem with parents in that project-oriented instruction looks different to them—and it is not the way in which they were taught."

Self-Assessment Tool for School Leaders: Technology and Transformation

The following questions are intended to guide you through a self-assessment of your district's and school's plan for technology and to assist you in determining some directions for integrating technology into your vision of learning. They are based in part on the Guiding Questions for Technology Planning, *Version 1.0, created by the North Central Regional Technology in Education Consortium (Knuth, 1996)—and on the information provided in this issue.*

	Fully	For the most part	Somewhat	Not at all
Technology and Our Vision of Learning				
1. To what extent have we clearly articulated a vision of learning for our school and district that incorporates key precepts of education reform?	❑	❑	❑	❑
2. To what extent does our vision of learning emphasize projects and the solution of real-world problems?	❑	❑	❑	❑
3. To what extent does our vision of learning incorporate technology as a key component that can promote a challenging curriculum and instructional practices that engage students (e.g., collaborative learning, problem-based learning, project-based learning)?	❑	❑	❑	❑
4. To what extent do our teachers, building principals, and other key staff understand their unique roles in this vision of learning and agree that technology needs to continue to be developed as a key tool to change instruction and learning?	❑	❑	❑	❑
5. To what extent does our vision of learning attend to the needs of students considered "disadvantaged" because of their socioeconomic status or other variables that may place them at risk of school failure?	❑	❑	❑	❑
6. To what extent does our vision of learning promote equity as we consider new uses of technology (e.g., programs to take laptops home, contracts with parents to use school equipment in return for classes)?	❑	❑	❑	❑
Technology and Professional Development				
1. To what extent have we developed a professional development plan that addresses the skills teachers will need to integrate technology into the curriculum?	❑	❑	❑	❑
2. To what extent have we budgeted sufficient monies for professional development and support for teachers and instructional staff that will increase both their knowledge base about technology and their understanding of engaged, authentic learning?	❑	❑	❑	❑
3. To what extent have we projected monies for professional development and technological support for school staff over a sufficient time period (e.g., five years)?	❑	❑	❑	❑
4. To what extent do our board of education and community members understand and support our professional development plan and its budget?	❑	❑	❑	❑

	Fully	For the most part	Somewhat	Not at all
5. To what extent have our teachers, building principals, and other staff had input into determining the type, content, and length of professional development necessary to integrate technology throughout their instruction?	❑	❑	❑	❑
6. To what extent does our professional development plan address how technology can accelerate and enhance learning for special needs students (e.g., economically disadvantaged)?	❑	❑	❑	❑
Technology and Equity				
1. To what extent do our plans for technology ensure that computers will be placed in a combination of classrooms and computer labs to ensure equitable access for all students in all content areas?	❑	❑	❑	❑
2. To what extent have we changed our methods of instruction to ensure that students who typically experience less challenging content and remediation can use technology to engage with challenging ideas and the solution of real-world, relevant problems?	❑	❑	❑	❑
3. To what extent have our staff, board of education, and community members discussed and planned for school-initiated ways in which computers can be used at home on a contractual basis with the school or district?	❑	❑	❑	❑
4. To what extent have we involved parents and family members in discussions of computer technology and ways in which they can help their children at home and also learn important skills?	❑	❑	❑	❑
5. To what extent do we monitor our instruction to ensure that one group or gender does not dominate access to computers?	❑	❑	❑	❑
Technology and Resources				
1. To what extent have we researched not only the amount of resources necessary to implement technology into our vision of learning, but also made plans to ensure we can acquire those resources?	❑	❑	❑	❑
2. To what extent does our plan for technology ensure equitable distribution of resources to all schools in our district?	❑	❑	❑	❑
3. To what extent does our budget for technology include adequate personnel to support teachers as they acquire the necessary knowledge to integrate technology throughout their instruction?	❑	❑	❑	❑
4. To what extent have we ensured that teachers will not be forced to compete for scarce resources both for hardware and software, but also for ongoing repairs, maintenance, and computer upgrades?	❑	❑	❑	❑
5. To what extent do our budget plans include incentives for teachers who seek out and acquire additional resources in the forms of grants or other monies to support the infusion of technology in their instruction?	❑	❑	❑	❑

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Resources From NCREL

The following resources are available from NCREL and are targeted to school leaders and school staff.

Learning With Technology: A Six-Session Course for Teachers of Grades 4-9

This course, developed by NCREL, is disseminated through its North Central Regional Technology in Education Consortium (NCRTEC) and is available through a select group of agencies licensed by NCREL. *Learning With Technology* focuses on enhancing teaching and learning through the use of technology. Course participants return to their classrooms with:

- Lesson plans and units that integrate technology into instruction.
- A planning framework and the expertise to use it to create their own lessons and units.
- A Participant's Manual that includes the planning framework, classroom scenarios, sample lessons, a guide to finding and using Internet sites, tips for evaluating software, and tools for using technology effectively.
- A network of colleagues to work with and learn from by means of a special Internet Web site and listserv.

For course prerequisites and to find out who offers this unique professional development course in your state, contact:

Sue Baker
NCREL
North Central Regional Technology in Education Consortium
1900 Spring Road, Suite 300 • Oak Brook, IL 60523-1480
800-356-2735, ext. 1269 • Fax: 630-571-4716 • E-mail: sbaker@ncrel.org

North Central Regional Technology in Education Consortium (NCRTEC)

The NCRTEC, housed within NCREL, is one of six Regional Technology in Education Consortia funded by the U.S. Department of Education's Office of Educational Research and Improvement (OERI). Its mission is to help schools and adult literacy programs develop technology-embedded practices that lead to improved and engaged learning for students. NCRTEC works to develop three fundamental areas:

- **Technology-Based Tools to Enhance Effective Teaching and Learning** (e.g., products and services for use by teachers and students, including instructional software, databases, and online curriculum projects)
- **Training and Professional Development** that includes products and services to provide learning opportunities for adults who might include principals, administrators, school board members, parents, and other educational stakeholders
- **Increasing Technology Capacity** or the tools and strategies to help schools and districts build the necessary technical infrastructure to sustain long-term technology integration

For more information, see http://www.ncrtec.org or NCREL's Home Page, which provides an overview of NCREL's many products, publications, and services at: http://www.ncrel.org

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Pathways to School Improvement Internet Server

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- Goals and Standards
- Governance/Management
- Leadership
- Literacy
- Mathematics
- Parent and Family Involvement
- Professional Development
- Safe and Drug-Free Schools
- School-to-Work
- Science
- Technology

Pathways to School Improvement can be found on the Internet at http://www.ncrel.org/ncrel/sdrs/pathways.htm

E-Rate: The Universal Service Fund Program Discounts for Telecommunications Services

The Universal Service Fund Program was established by the Federal Communications Commission to ensure that schools and libraries have access to affordable telecommunications services. This fund—also called the E-rate—will provide private and public K-12 schools and public libraries with discounts of from 20 to 90 percent on telecommunications and Internet services and on the installation and maintenance of the network necessary to provide classroom access to these services. Up to $2.25 billion per year will be available from the fund, which will be in effect on January 1, 1998. Consortia may be formed with qualifying institutions in order to achieve lower pre-discount prices. The discount is based on the percentage of students who are eligible for the federal free- and reduced-price school lunch program and on whether the institution is located in an urban or rural area. The following services are eligible for discount:

- Telecommunications services such as basic phone service, leased data circuits, T-1/ 56Kbps/ISDN lines, dial-up Internet access, direct Internet connections, e-mail, and wireless connections
- Internal connections, such as telecommunications wiring, routers, switches, hubs, network servers, certain networking software, wireless LANs, and PBX
- Installation and basic maintenance for the internal connections

The Schools and Libraries Corporation (SLC) mailed application forms to all schools and libraries on December 11. A Web site is being created as part of the application process and is expected to be operational after January 12, 1998. For more information, contact the SLC by phone at 1-888-203-8100 or by email at question@slcfund.org. The SLC Web site address is: **http://www.slcfund.org**

The following Web sites provide current information on the E-rate:

http://www.ed.gov/Technology

http://www.ncrtec.org

http://www.ncrel.org/sdrs/timely/erate/e-rate.htm

http://www.eratehotline.org/

http://www.fcc.gov/learnnet

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North Central Regional Educational Laboratory
1900 Spring Road, Suite 300
Oak Brook, Illinois 60523-1480

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